

1 Description

2  
3 Method, intermediate station and central control device for the  
4 packet-switched transmission of data in a self-organizing radio  
5 network

6  
7 The invention relates to a method for the transmission of data  
8 in a self-organizing radio network in accordance with the pre-  
9 amble of claim 1, an intermediate station in accordance with  
10 claim 8 and a central control device in accordance with claim  
11 9.

12  
13 It is known that the stations in a local network (LAN) are gen-  
14 erally linked to each other via cables. However, networks of  
15 this type are increasingly being replaced, or at least supple-  
16 mented, by radio networks which function, for example, accord-  
17 ing to the WLAN standard (IEEE 802.11).

18  
19 Radio networks of this type can in principle be divided, ac-  
20 cording to the nature of the medium access method used, into  
21 decentralized networks, for example a network which employs the  
22 "Distributed Coordinated Function (DCF)" in accordance with  
23 IEEE 802.11, and centralized networks, for example structured  
24 in accordance with the Hiperlan/2 or Bluetooth standard.

25  
26 In a central network, a radio coverage area (cluster) is pro-  
27 vided with a central control unit (central controller) which  
28 regulates access to the resources (transmission medium or me-  
29 dium) by the stations located within the radio coverage area.  
30 For example, as shown in Figure 1, a transmission of data by a  
31 station within the cluster does not take place until the sta-  
32 tion has been informed by the central controller of the re-  
33 source to be used, whereby under Hiperlan/2 this takes place in  
34 such a way that all the stations which wish to transmit first  
35 transmit a so-called "Resource Request" (RR) to the central  
36 controller, which for the purpose of authorizing the data  
37 transmission then communicates to the station concerned a "Re-  
38 source Grant" (RG) within a transmission frame defined in ac-

cordance with the radio interface. The central controller also indicates its own data transmissions with an RG in the same MAC frame. In accordance with the Hiperlan/2 standard, the RG messages contain items of control data for the data transmission. In both cases, these are essentially the identifications of the transmitter and receiver, a link identification, number and nature of the transport channels, time point for the start of the transmission, and the nature of the encoding and modulation schema to be used on the physical layer. "Resource Grant" messages are transmitted by the central controller at the start of the MAC frame via the so-called "Frame Channel" (FCH).

From "J. Habetha and M. Nadler, Concept of a wireless centralised multihop ad hoc network", in "Proc. European Wireless, Dresden, Sept. 2000", it is also known that a centralized Hiperlan/2 network consists of several clusters, each of which has a central controller. A network extended in this way, from one cluster to several clusters, is referred to as a so-called multi-cluster network, and takes a form such that the central controllers control access to the media independently of each other, this being achieved by a reuse factor of greater than 1, where the term "Reuse Factor" refers to the distance between radio coverage areas at which the resources used, i.e. in general the frequencies which are available, recur.

With a derivative of the system described above, it is also possible to allocate to the central control units of the clusters, as the resources to be administered, non-overlapping periodic time intervals on one single frequency, rather than different frequencies.

In this situation, it is advantageous to subdivide the transmission bandwidth into as few resources as possible, which can be achieved by the distances between the central controllers being large, wherever possible. For this purpose, because of the distance, an advantageous requirement for the exchange of data between any two neighboring radio coverage areas is intermediate stations (forwarding nodes) located in the area where

1 the radio coverage areas overlap, and which can therefore be  
2 assigned to two clusters.

3  
4 A disadvantage of the networks described is that the transmis-  
5 sion of data between two clusters which are far apart involves  
6 several intermediate stations and central controllers, which  
7 therefore occupies their resources, and in addition a delay oc-  
8 curs due to the resource allocation methods for the intermedi-  
9 ate stations involved, as can be seen from the data flow shown  
10 in Figure 1.

11  
12 The object underlying the invention is to specify a method  
13 which makes possible the efficient exchange of data in a self-  
14 organizing multi-cluster network.

15  
16 This object is achieved, starting from the method for data  
17 transmission in a self-organizing radio network in accordance  
18 with the preamble of claim 1, by its characterizing features,  
19 by the intermediate station in accordance with the characteris-  
20 tics of claim 8, and by the central control unit in accordance  
21 with the characteristics of claim 9.

22  
23 With the method in accordance with the invention for packet-  
24 switched data transmission in a self-organizing radio network,  
25 with at least one first and one second radio coverage area, to-  
26 gether with at least one mobile communication device for each  
27 radio coverage area, whereby a first device is operated in the  
28 first radio coverage area, and a second device in the second  
29 radio coverage area, for the purpose of central control of the  
30 assignment of the transmission channels assigned to the radio  
31 coverage area concerned, and mobile communication devices are  
32 operated both in the first and also in the second radio cover-  
33 age area as intermediate stations, for forwarding to the second  
34 radio coverage area data originating in the first radio cover-  
35 age area, where the forwarding takes place in such a way that  
36 the first central control device controls the transmission  
37 channels available to the first radio coverage area, both for  
38 transmission of data between the first central control device

1 and the intermediate station and also for the transmission of  
2 data between the intermediate station and the second central  
3 control device.

4  
5 The result of the method in accordance with the invention is  
6 that any delay to the transmission of data packets, arising  
7 from their being forwarded, is minimized. Apart from any other  
8 effects of the method in accordance with the invention, inter-  
9 mediate stations can be more simply operated. In addition, in  
10 contrast to methods known from the prior art, a packet which is  
11 to be transmitted to a remote radio coverage area need in each  
12 case only be processed once by the packet scheduler of the cen-  
13 tral control unit. Because the first central control unit con-  
14 trols the assignment of resources both for the (partial) trans-  
15 mission of a data packet to the intermediate station and also  
16 for the (partial) transmission to the next reachable second  
17 control unit, the number of requests and answers for the pur-  
18 pose of assigning resources is reduced, so that the available  
19 resources are more efficiently used. A further concentration of  
20 functions onto the central control unit is also achieved, so  
21 that those communication terminal devices which are operated as  
22 intermediate stations are freed of additional tasks, and need  
23 provide less complex functions.

24  
25 Preferably, the control data which is appended will be trans-  
26 mitted on a separate transmission channel, in particular an FCH  
27 channel, if it can be ensured that the second control unit can  
28 receive the first control unit's FCH channel. This renders it  
29 unnecessary to add content to the data which is to be for-  
30 warder. In addition, significantly fewer intermediate stations  
31 are involved, because the control data can be decoded directly  
32 by a receiving central control device. Control channels of this  
33 type can have encoding which is more robust in respect of  
34 transmission errors, for example "Binary Phase Shift Keying",  
35 BPSK, so that control data which is transmitted on these con-  
36 trol channels can be received over a greater radius. In this  
37 case payload data could in principle also be transmitted di-  
38 rectly and just as robustly with no intermediate stations from

1 the first to the second control unit. However, when an interme-  
2 diate station is used the transmission can be more efficient in  
3 terms of the network resources occupied than with a direct  
4 transmission, if the split into two transmissions makes it pos-  
5 sible to use higher quality encoding and modulation on both  
6 links.

7  
8 Alternatively, if the FCH channel cannot be received by the  
9 second central control device, the intermediate station appends  
10 to the data which is to be forwarded the control data for the  
11 second central control device. This is particularly advanta-  
12 geous when the second central control device is not within ra-  
13 dio range of the first central control device. In such a case,  
14 the items of control data added to the data can be forwarded by  
15 the intermediate station and decoded by the second central con-  
16 trol device. By this means, the second control device is given  
17 further details about the data forwarded by the intermediate  
18 station, which puts it in a position to decode the data and re-  
19 ceive it without errors.

20  
21 This approach, of appending control data to the payload data  
22 channels, can also be used as an enhancement. For example, a  
23 development is conceivable by which, if the receipt of the FCH  
24 channel deteriorates due to an increase in the distance between  
25 the first central control device and the second central control  
26 device, or due to other influences, the first central control  
27 device instructs the intermediate station to forward the con-  
28 trol data for the RG message via the payload data channel or,  
29 if there is an improvement in the reception situation, with-  
30 draws the instruction again.

31  
32 In doing this, the control data in the RG message which de-  
33 scribes the transmission (with the exception of the time point  
34 of the transmission) will preferably be appended to the data  
35 which is to be forwarded. By this means, the receiver of the  
36 data which is to be forwarded is defined. In addition, it con-  
37 tains for example notes on the encoding of the data, which en-  
38 able the data decoding to be suitably adapted.

1  
2 The data may, for example, not terminate in the radio coverage  
3 area of the second central control device, but this radio cov-  
4 erage area may represent simply a link in a connecting chain of  
5 radio coverage areas through to the data's destination. In such  
6 a case, the approach in accordance with the invention will be  
7 appropriately repeated, so that a cascade-like interaction  
8 through to the data's destination is realized.

9  
10 Facilities for carrying out the method explained above are pro-  
11 vided by the intermediate station in accordance with the inven-  
12 tion, thus enabling an implementation of the method for estab-  
13 lishing an improved communication system.

14  
15 Facilities for carrying out the method explained above are pro-  
16 vided by the central control device in accordance with the in-  
17 vention, thus enabling an implementation of the method for es-  
18 tablishing an improved communication system.

19  
20 Further advantages and details of the invention are explained  
21 by reference to the figures. These show:

22  
23 Figure 1 a data flow in accordance with the prior art,???

24  
25 Figure 2a CCx and CCy mutually within range (Case A),

26  
27 Figure 2b CCx and CCy out of each other's range (Case B),

28  
29 Figure 3a a dependency on the effect of the signal sequence  
30 generated by the method in accordance with the inven-  
31 tion for the arrangement shown in Figure 2a,

32  
33 Figure 3b a dependency on the effect of the signal sequence  
34 generated by the method in accordance with the inven-  
35 tion for the arrangement shown in Figure 2b,

36  
37 Figure 1 shows a Medium Access Control data flow, as imple-  
38 mented in accordance with the prior art. It can be seen that

1 for the forwarding of data DATA a sequence of data packets RR,  
2 RG are dispatched for the allocation of resources. This delays  
3 the forwarding of the data DATA, and in addition occupies pay-  
4 load data transmission resources.

5  
6 Figure 2a illustrates a model of a possible arrangement of a  
7 wireless communication system, as is also known in networks  
8 known from the prior art, and in which the method in accordance  
9 with the invention is employed. The illustration shows a first  
10 central control device CCX, an intermediate station FNX to-  
11 gether with a second central control device CCY. Also to be  
12 seen are a first radio coverage area which is provided by the  
13 first central control device CCX and a second radio coverage  
14 area which is provided by the second central control device  
15 CCY, where the first and second central radio coverage areas  
16 have a range within which payload data can be exchanged with  
17 mobile terminal devices, and the ways of achieving which in-  
18 clude the type of modulation or the encoding, as applicable -  
19 in the example this is 16 Quadrature Amplitude Modulation  
20 (16QAM).

21  
22 Also to be seen are a third radio coverage area and a fourth  
23 radio coverage area, which have greater ranges than those of  
24 the first radio coverage area and the second radio coverage  
25 area due to the nature of the modulation used for transmission  
26 of the control data, that shown in the example being Binary  
27 Phase Shift Keying (BPSK).

28  
29 For the exemplary embodiment shown, it can be seen that in re-  
30 spect of the transmission of control data each of the central  
31 control devices CCX, CCY is located within range of the other  
32 control device. The BPSK channel provided for the transmission  
33 of the control data, designated FCH in accordance with the ex-  
34 emplary embodiment, can thus be used in accordance with the in-  
35 vention in such a way that control data, such as for example  
36 the receiving address and the format of data which is to be  
37 forwarded, is transmitted directly, from the first central con-  
38 trol device CCX to the second central control device CCY and in

1 the reverse direction. Further forwarding to a third central  
2 control device (not shown) can then be initiated from the sec-  
3 ond central control device CCY. By such a connection from one  
4 to another (cascading) of forwarding activities, realized in  
5 accordance with the invention, even very large distances can be  
6 spanned. Because the items of control data are transmitted di-  
7 rectly to each of the control devices involved, the intermedi-  
8 ate stations involved can be operated, without extensive  
9 changes, in accordance with the inventive method, and the main  
10 content of the modifications required in connection with the  
11 implementation of the method lies in the central control de-  
12 vices.

13  
14 An alternative arrangement is illustrated in Figure 2b. The ar-  
15 rangement shown contains elements which are already known from ,  
16 the previous arrangement, and which are therefore labeled with  
17 the same reference characters. It can be seen that the first  
18 central control device CCX and the second central control de-  
19 vice CCY can no longer communicate with each other via control  
20 data channels. Only the intermediate station FNX is, as before,  
21 located within range for a data transmission on payload data  
22 channels, both toward the first central control device and also  
23 toward the second central control device CCY.

24  
25 It is of advantage for the arrangement described if, in accor-  
26 dance with the invention, the control data RG2 (see Figure 2)  
27 is attached to the data to be forwarded (shown as Case B in  
28 Figure 2), so that the second central station CCY can decode  
29 and analyze it, in order to be able to transport the data which  
30 is to be forwarded to the desired destination.

31  
32 With the arrangement shown, the second central control device  
33 CCY must be able, at arbitrary times which are outside the time  
34 resources assigned to the second central control device CCY, to  
35 detect the transmissions which are part of a forwarding activ-  
36 ity. This is achieved by a special burst format. Here, it



1 should be noted that, because of the separation in the time do-  
2 main between the radio coverage areas, the second central con-  
3 trol device CCY can receive the data forwarded by the first  
4 central control device CCX and/or by the intermediate station  
5 FNX.

6  
7 The main advantageous effect of the method in accordance with  
8 the invention can be seen from Figure 3a, which shows a Medium  
9 Access Control data flow resulting in accordance with the in-  
10 vention.

11  
12 It can be seen that data DATA which is to be forwarded is  
13 transmitted from the first central control device CCX to the  
14 intermediate station FNX, and from there without delay to the  
15 second central control device CCY. This happens because, by  
16 comparison with the data flow in accordance with the prior art,  
17 described and shown above, due to the method in accordance with  
18 the invention no resource request queries, which are generally  
19 offset in time relative to the data DATA, arise.

20  
21 This also has the advantage that the available resources are  
22 not occupied by messages of this type.

23  
24 Also shown is the use of resources in the case of forwarding in  
25 accordance with the inventive method. It can be seen that the  
26 data DATA to be forwarded comes to the second central control  
27 device CCY in the time resource of the radio coverage area pro-  
28 vided by the first central control unit CCX.

29  
30 Apart from the advantages already explained, this also avoids  
31 entering packets into transmission queues. In addition, inter-  
32 mediate stations are freed of IP router functions, which leads  
33 to a further reduction in the complexity of the intermediate  
34 stations.

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